JPRS: 18,383

27 March 1963

OTS: 63-21432

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- USSR -

U. S. DEPARTMENT OF COMMERCE
OFFICE OF TECHNICAL SERVICES
JOINT PUBLICATIONS RESEARCH SERVICE
Building T-30
Ohio Dr. and Independence Ave., S.W.
Washington 25, D. C.

Price: $.50

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/Following is the translation of an article by N. M. Kozhov and N. V. Tyumentsev in the Russian-language publication Byulleten' Moskovskogo Obshchestva Ispytateley Prirody, otdel biologii (Bulletin of the Moscow Society of Naturalists, Biology Department), Vol LXVI (3), Moscow, 1961, pages 32-39./

[1-2]

With the building of the Irkutskaya GES [Hydroelectric Power Station] on the Angara River, Lake Baikal in effect has begun to serve as a reservoir, through which it is expected to regulate the inflow of water required for the normal functioning of the hydroelectric station. Such regulation can be accomplished only as a result of changes in the water level of the lake.

According to existing material, the average, over many years, level of Lake Baikal (over the last 60 years) has been determined at 455.6 m (from the level of the Pacific Ocean). The highest level observed during the 60-year period equalled 457.14 m. The lowest, recorded on 2 April 1904, was equal to 454.92 m. Thus, the amplitude of absolute fluctuation in the level of Baikal water over a long period is equal to 2.22 m.

During the period of preparing for hydroelectric station construction on the Angara River various suggestions have been put forth and discussed aimed at using Lake Baikal for power purposes. According to designs put forth even as far back as 30 years ago by Academician I. T. Aleksandrov, Professor V. M. Malyshev, and P. M. Dmitriyevsk aimed at the best regulation of the inflow of water from Lake Baikal into the Angara River, it was suggested that the level of Baikal water be raised, using the dam of the Irkutskaya GES by 1.5-2 m above the present level. According to this project, the dam of the Irkutskaya GES has been built, and all large settlements and structures have been removed from the proposed zone of flooding of the Lake Baikal banks.

In 1957 the Gidrostroyproyekt /Gosudarstvennyy Institut po stroitel'nomu i rabochemu proyektirovaniyu gidroenergouzlov; State

Institute for the Constructional and Operational Designing of Hydroelectric Power Networks/ put forth new suggestions for a broader use of Baikal for power purposes. It was suggested to make a cut in the flow of the Angara River by means of a powerful explosion at a depth of 25 m, a width at the top of 100 m, and a length of 9 km.

Such a deepening of the course of the Angara River would have made it possible to alter the level of Lake Baikal down to 4-5 m below the present level and assure the control of water inflow from Lake Baikal for the entire Angara-Yenesei Cascade. This project, reported by N. A. Grigorovich to engineers at the Conference for the Development of the Productive Forces of East Siberia in 1958 in Irkutsk raised serious objections and at present it is deemed advisable not to permit any tampering with the level of Lake Baikal below its natural perennial level (454.92 m), but to increase the carrying capacity of the Angara River by lowering the bottom of its channel 2 m below the present level.

It can be suggested that with further expansion of hydroelectric station construction on the Angara, the Yenesei, and other large Siberian rivers projects aimed at using Lake Baikal for power purposes by reducing the level of its water within the permissible amplitude of such level fluctuation which would substantially exceed the natural fluctuation may again be put forth. Therefore, it is extremely important to clearly represent the changes which would take place in the life of the lake, representing a unique environment in the distinctiveness of its natural life.

First of all we must become acquainted with the changes which would take place in the life of the lake as a consequence of natural seasonal and perennial fluctuations of its level.

The seasonal fluctuations of the level of Lake Baikal water in years of low precipitation have an amplitude up to 60-80 cm, and in years with a high precipitation rate up to 1.2-1.4 m, in which the minimum level will appear in early spring (April - May), and the maximum in autumn (September - October), sometimes even by August. By spring the low-lying banks of the lake are exposed in a belt up to several hundreds of meters in width. By autumn before the frost mobile organisms move from the breaker-zone (crustaceans, mollusks, bullheads, etc.) to deeper zones, several species of oligochaetae dig deep into the bottom.

Under the conditions of flow regulation the seasonal fluctuation in the lake level will be very minor. As a consequence of this we can anticipate a certain worsening of the conditions of life in the littoral zone by the end of the summer and in autumn, a certain shallowing of the near-shore area of spawning rivers, which must to a certain extent worsen the conditions for the departure of the Arctic Sea whitefish /Coregonus autumnalis/ (August - September - October) for spawning in the rivers. A worsening can be anticipated during autumn in the oxygen level

in sor /a salina in Kazakhstan and Central Asia/, especially by the end of winter. As far as the Arctic Sea whitefish is concerned, the positive effects of abundant precipitation are related not so much with a high level in the lake water as much as with increased flowrate of the rivers, due to which the aeration of the eggs is improved, sharply reducing freezing of the spawning grounds, etc.

Years of minimum level have, on the other hand, a sharply negative effect on the life of the lake inhabitants. During such years sizable portions of the bottom along the low-lying banks become exposed, the spawning grounds of chastikovyye /?/ fish shrink, and the fattening areas for the young of all fish becomes decreased, by the end of winter the gas conditions of the sor worsen due to the shallowing and freezing of the sor.

With a regulated flow and artificial decrease or increase beyond the limits of the natural fluctuations, all these effects will undoubtedly be greatly intensified.

Let us now look at those consequences which can be expected from increasing the lake level.

Upon increasing the level of Baikal water by 2 m above the perennial mean level in the region of the delta of the Kichera and Angara rivers, the inundated area will amount to almost 50,000 hectares, the waters covering a stretch upwards along the Kichera for 50 km. Thus, an enormous new body of water with a depth of about 1-1.5 m will be formed. In the region of the Barguzinskiy neck of land (Barguzinskiy and Chivyrkuyskiy Bays), the total inundated area will come to 31,000 hectares. New bodies of water also will be shallow -- with depths of 1-2 m. In the region of the Selenginskiy shallows the Selenga delta will be flooded, and also the lowland parts of the bank to the north and to the south. In all up to 55,000 hectares will be inundated.

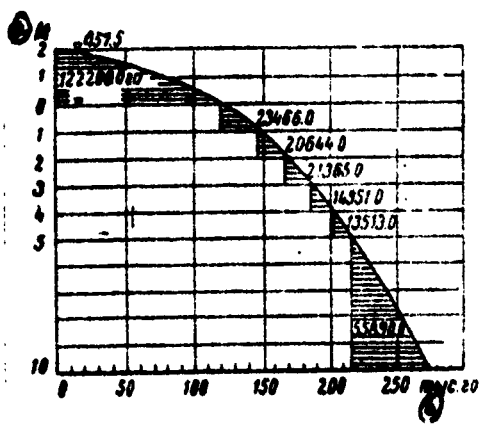

Figure 1. Areas of the extent of Baikal littoral (according to N. V. Tyumentsev); mean average, over many years, equal to 455.6 m. LEGEND: a) meters; b) thousands of hectares.

If we add to the figures indicated the depressed parts of other regions of Baikal, then upon increasing the Baikal level above that of the perennial mean level by 2 m, approximately 140,000 hectares of littoral depressions will be inundated, and allowing for islands emerging above the water level -- 120,000 hectares.

Upon raising the level by 1.5 m the flooded area will evidently be not less than 100,000 hectares. The significance of these figures will be clear if it is recalled that the entire present zone of 0 to 5 m depths in Lake Baikal amounts to only 93,000 hectares, and the depth zone of 0-3 m -- about 66,000 hectares. Thus, after an increase in the level of 1.5-2 m above the perennial mean figure the area of shallows of Lake Baikal having depths of 0.5 to 0.3 m will be increased, respectively, by 50% and by 100%.

G. Yu. Vereshchagin believes that such a flooding of the shore-side depressions will have a substantial positive value for the productivity of the "sor" fish. He writes that, "if at present (in the 1930's) the catches of sor fish in Lake Baikal come to 20,000 centners, then for the same catch intensity the quantity of caught fish must be increased almost two-fold and amount to about 40,000 centners, and under conditions of intensified fishing together with reclamation measures and acclimatization of new fish varieties, this figure can be further increased almost two-fold." (Vereshchagin, 1937)

However, such prospects for fishing industry upon increasing the level are unquestionably very much overstated. The greater part of the flooded lowlying banks at present are boggy, covered over by close-packed vegetation, hillocks, peat bogs, underbrush, and patches of forest, which it is not suggested to eliminate. During the first years following inundation this zone will not only be weakly productive but of limited access to large industry. Observations on the settlement of large reservoirs have shown the extreme tardiness of the process of transforming flooded depressions to sufficiently productive commercial land. But it is most essential that the effect from increase in the level will be short-lived, since the increased level can only be temporary. But in any case, as was correctly noted by G. Yu. Vereshchagin, increasing the level of Lake Baikal and substantially extending the area of the wellwarmed shoals will play only a positive role in the state of lake waters and in their bio-productivity.

We turn to a discussion of the consequences of a decreased level. In order to clearly understand the importance for the life of Lake Baikal of decreasing its level, it is necessary to refer above all to the very weak development in the Baikal shoals, especially along the open rocky shores, which predominate in Lake Baikal (cf Table).

The width of the zero-two, zero-three m depth zone along such shores usually amounts to only a few tens, and infrequently a few hundreds, of meters. Figures 2 and 3 represent the profile

of the bottom of the littoral zone of the lake, obtained by means of detailed photography in recent years, and Figure 1 shows the mean slope for the Baikal basin. Along the rocky shores the slope of the bottom, at first very gradual, dips down sharply into the deep even at a depth of 2-3 m, and almost immediately inter grades into the native and generally very steep basic incline of the lake basin. Along the shores made up of loose deposits the slope of the bottom is more gradual, but still here also a sharp dip occurs at a depth of about 3-5 m.

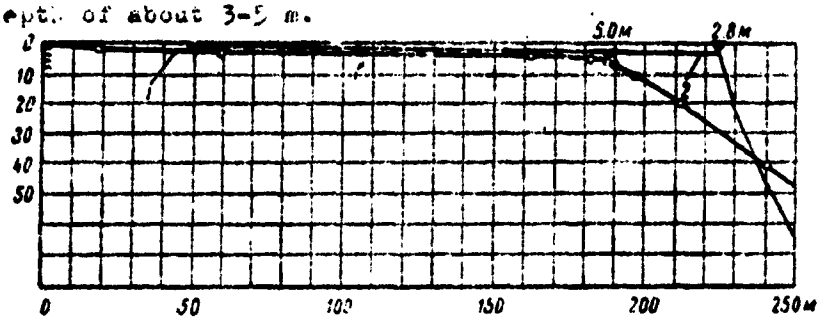

Fig. 2. Profiles of underwater abrasional platform of Lake Baikal (according to N. V. Tyumentsev): 1 - mean profile of underwater slope of a 10-km section of the west shore of Lake Baikal; 2 - characteristic profile of the open slope over the same section.

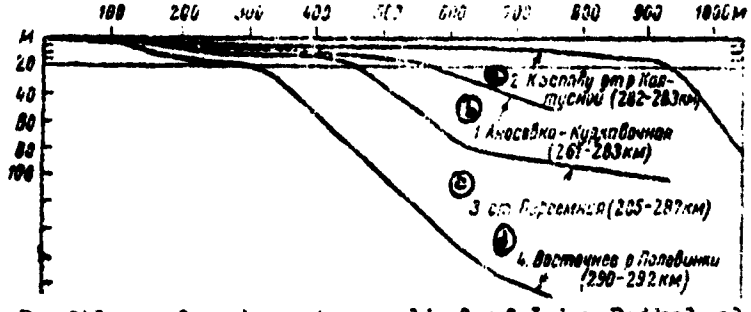

Fig. 3. Profiles of underwater relief of Lake Baikal along its southeast shore (according to N. P. Ladokhin). LEGEND: a) 2. Toward west from Kalmusnaya River (282-283 km); b) 1. Anosovka-Kurkavochnaya (261-283 km); c) 3. from Pereyemnaya (285-287 km); d) 4. Easterly along Polovinka River (290-292 km).

In the region of the issue of large rivers (Selenga, Upper Angara, Kichera, Barguzin, and Turka) and in large shallow bays the bottom slope is in effect gradual to a depth of 10-15 m, after which the bottom also breaks off sharply toward the deep.

From the data presented it follows that upon decreasing the level of Baikal waters only by 2-3 m below the mean averaged

TABLE

Area of the Shoals in Lake Baikal (according to N. V. Tyumentsev)

a) Глубина, м	b) Площадь, га (с сором Рангатуй)	
0— 1	23 466	44 110
1— 2	20 644	
2— 3	21 365	19 869
3— 4	14 901	
4— 5	13 513	
0— 5	93 979	
5—10	55 800	
0—10	149 779	
10—20	77 918	
0—20	227 697	

LEGEND: a) Depth, m; b) Area, in hectares (from the Rangatuy sor).

over many years, the shoal platform along the rocky shores with its especially rich endemic fauna, serving as the habitat for numerous benthic fish and especially the grayling [Thymallus], will disappear to a large extent. There the clusters of Baikal endemic macrophytes densely inhabiting the rich fauna of endemic crustaceans, turbellaria, caddisfly [Trichoptera], molluscs, and other native inhabitants of Baikal, would especially suffer. Such sizable areas in these regions would be exposed as represented by the following figures, the pre-estuary of Selenga (up to 29,000 hectares), Kichera and Upper Angara (up to 5,000 hectares), Chivirkuyskiy Bay (up to 10,000 hectares), the Maloye Sea (up to 5,000 hectares), etc.

In addition, it is well known that the shoals represent the "granaries" of Baikal. In the zone of 0-3 and 0-5 m depth a large part of the bottom vegetation is concentrated, forming a food source for numerous herbivorous and detritus-eating animals. The biomass of the zoobenthos here ranges within the limits of 500-1000 kg/hectare, and higher. Therefore, here almost all the benthic fish of Baikal live and thrive. The young of all commercial fish find their food and shelter from enemies among the clusters of macrophytes. The chastikovyye [?] fish of older ages, migrating during the summer along the shores, keep to the zone of 0-3-meter here. The omul [Salmo omul] young during the first months of life, leaving the spawning rivers in April - May to come to Lake Baikal, stay in the warm part of the shoals, in the inlets, the bays, the sors [Maslina in Kazakhstan and Central Asia], etc. Decreasing the area of these shoals by 50 and 100% will lead to a sharp drop in the survival rate of the omul young, will worsen the conditions of omul departure for rivers during the spawning season by making the pre-estuary sections shallower, will eliminate the spawning grounds of sor fishes, and will affect the spawning areas of the whitefish.

It is also important to note that the shoals promote the heating of the water of neighboring deep-water parts of the lake. The warm waters of the shoals due to currents are spread throughout the neighboring regions, warming up the upper layers of water and speeding up the development of life therein, especially plankton life.

According to the roughest calculations, decreasing the level of Baikal water by zero-five m can lead to such a sharp drop in its fish productivity that the industry will lose not less than 50,000 centners from the present 100,000-120,000 centners of gross annual catch, of which more than half of the loss will be represented by such valuable species as the omul, the grayling, and the whitefish. Even a drop in the lake level of 2-3 m will harm the hydrobionts of Baikal only a little less, since the exposed area of the littoral in this case also will amount to not less than 44,000-65,000 hectares and an annual loss to fishing, as we estimate it, of not less than 30,000-40,000 centners of fish.

Considerable damage to the fauna of Baikal and the fishing industry will result even upon reducing its level by only 0.6-1 m below the mean figure, since also in this case the area of the shoals will be decreased by more than 20,000 hectares.

As has already been said, it is assumed that to regulate the outflow of water from Baikal into the reservoir system of Angara-Yenisei Cascade the Baikal level will vary as a function of the abundance of rain and the electric power needs. A great difficulty in determining the consequences of such level changes is the fact that we cannot precisely predict what the duration of the relatively stable levels will be and how rapidly rises and descents in its levels will occur. The Gidroenergoproyekt in predicting its developments, bases its work on the graph of natural fluctuations in Baikal water levels during the last sixty years. However, this graph gives only the most general picture of the possible periods and amplitudes of fluctuation. It is most probable that a shift in the high precipitation and low precipitation periods will take place not at all as has been the case during the last sixty years. In any case even if the amplitude of such fluctuation amounts to no more than 2-3 m, the shoreline of Baikal will be shifted along the low-lying banks within very broad limits.

With an amplitude of fluctuation of 2 m (457-455 m) the shore in the region of the Selenga delta will be displaced within limits of from 1-2 to 6-8 km. For an amplitude of fluctuation of 3-5 m the width of periodically dry and flooded depressions in several areas will come to 10-18 km. Such displacements in the shoreline undoubtedly would lead to great complications in the management of the fishing industry, since the shorehauls will be shifted to less convenient and unsuitable sections. The performance of shore-fishing industry structures and ports will be disorganized.

With a curtailment in the amount of water and a change in the level of Lake Baikal it can be anticipated that the biocenoses in the litteral sheal zone will always be found in a changing state, which in itself will act adversely on their productivity.

The figures referred to of the possible harm to the fishing in Lake Baikal were determined on the basis of very selective fish reserves over the last decade. At the present-day (unmodified) level of Baikal water these reserves, and consequently the fish hauls, do not match the potentials of the lake. It is most probable that the fish reserves can be increased by at least 50 to 100%, both for omul and for the chastikovyye kinds, that is, a gross catch of at least up to 200,000 centners annually. To achieve this, a plan of extensive and wholly practicable measures has been worked out, which measures include the careful preservation of the spawning period of commercial fish, the setting up of preserves for the fry, reclamation of spawning grounds and places of access to them, development of massive artificial fish hatcheries, the acclimatization of new fish species, etc. However, if fluctuations of a broad amplitude exist in the lake level, these measures cannot be realized entirely, due to displacements in the fishes' spawning areas in the lake and changes in the sites of growing young.

With all this material and consideration of consequences, we believe that in using Baikal for power purposes its level must not be lowered below the minimal natural mark of 455 m, and the amplitude of fluctuations in lake level, averaged over many years, cannot exceed 2 m, that is, the figures observed to be the maximum over the past 60 years.

Baikal is an outstanding phenomenon of nature and it must be protected as a national achievement of the Soviet people. Thus it will be passed on to future generations. Any encroachment on its integrity for temporary gain would be improper. Neither can its fishing riches be neglected, since their value lies not only in their numbers. Baikal is in the center of a vigorously rising new gigantic industrial nucleof our country. The population of the Pribaykal'ye /Baikal region/ and the Priangar'ye /Angara region/ are growing rapidly and are in much need of high-quality fish, which can easily be brought fresh to the consumer due to the availibility of water routes, and no importation of canned fish from distant seas can displace this source of high-vitamin content food. We believe that in any designs made on the use of Baikal water for power purposes, the positions presented above must be kept in mind.

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